TRACE ELEMENT CHARACTERIZATION OF DECEPTION ISLAND TEPHRAS: IMPLICATIONS FOR THE ORIGIN OF MAGMAS ASSOCIATED TO RECENT VOLCANISM

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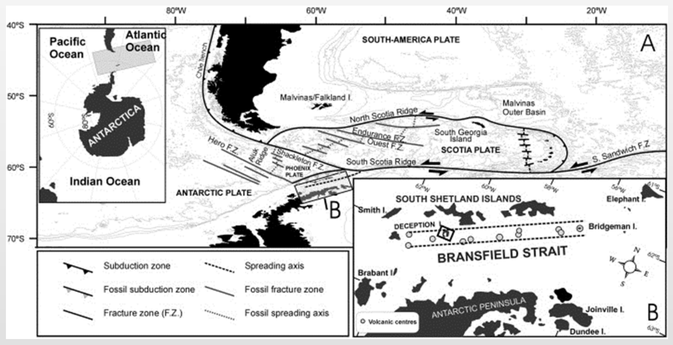
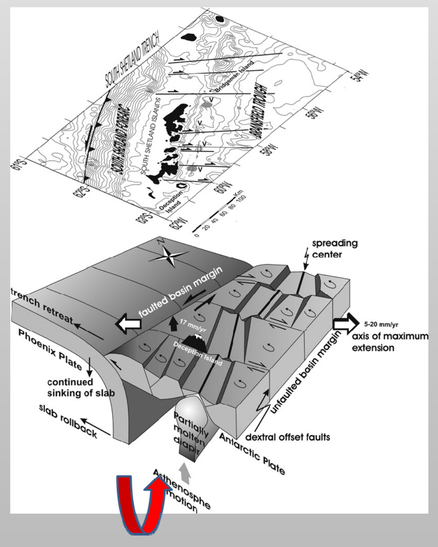
1. INTRODUCTION



Deception Island located in the border of the Antarctic Plate, but in a region of highly tectonic complexity whereas a subduction zone, a back-arc basin and 3 plate tectonics co-exist[1].

Deception Island belongs to a chain of islands (South Shetland Islands) which are separated from Antarctic Peninsula by the Bransfield Strait, which has only 100 km wide, 400 km long and 2 km depth, corresponding to a back-arc basin.

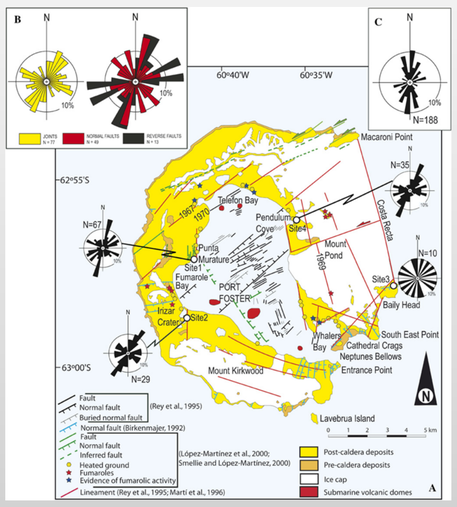


It is proposed[2] that after subduction, the passive sinking of the Phoenix Plate gives rise to trench rollback which creates a correspondent asthenospheric upraise motion, allowing the adiabatic partial melting at the origin of the back-arc basin magmas.

Given such complexity in the tectonic settings, it is expected to find great variability in the magmas geochemistry, as already documented[3], along the volcanic arc where lavas range from tholeiitic to calc-alkaline character. It is also envisage that such variability could be extended to the magma mantle sources too.

Given this scenario we can ask: <u>Is the younger volcanism of Deception Island connected to the subduction or, alternatively, related to the rifting leading to the opening of the marginal basin?</u>

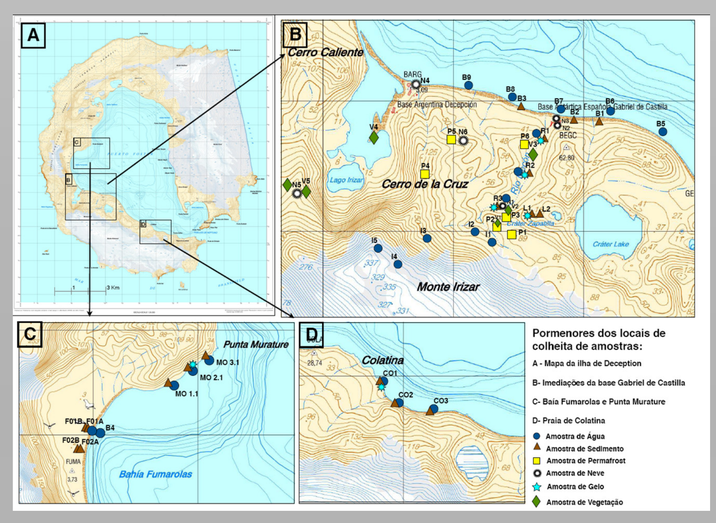
2. GEOLOGIC SETTING OF DECEPTION ISLAND AND SAMPLING



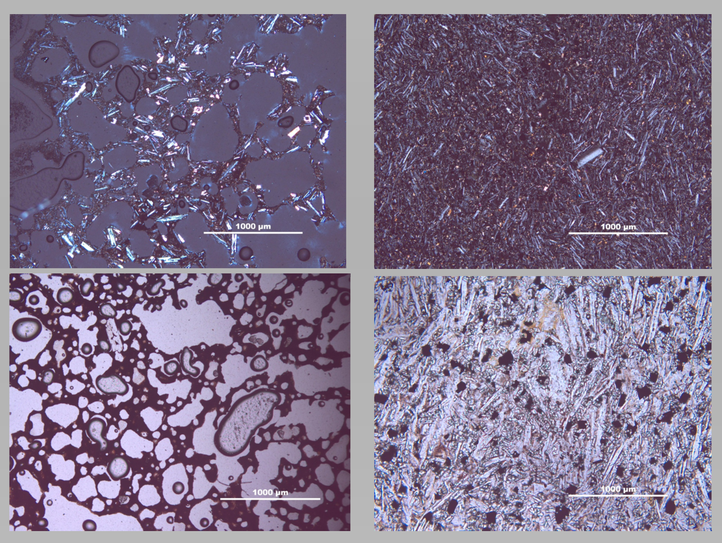
- **Deception Island is a classic Volcanic Caldera 9 Km diameter (Collapsed volcano) (the age of the caldera is unknown)**
- **It has a submerged basal diameter of c. 30 km and rises to 500 m at Mt Pond**
- **The stratigraphical sucessions of the Quaternary volcanic sequence at Deception is mainly the division into <u>Pre- and Post- caldera formations</u>**
- **Post-caldera activity comprised numerous small pyroclastic cones**
- **The volcanism is active and recent, with 3 volcanic eruptions in 1967, 1969 and 1970.**

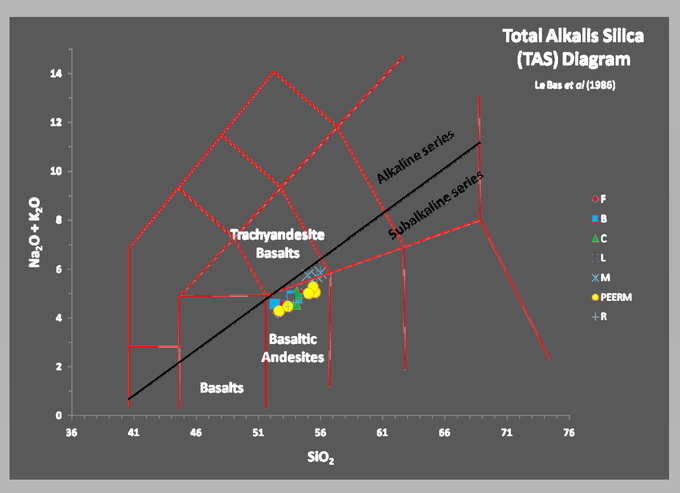
Integrated in the CONTANTARC[3] project, a set of 32 volcanic samples, collected in different environmental (lake, smokers, beaches, permafrost and rivers) and geographic settings of the Deception Island were studied.

The rocks studied are called TEPHRA (specifically Lappilli - dimensions between 2-64 mm), which correspond to pyroclastic volcanic rocks that were produce by explosive volcanism as the result of magma fragmentation.

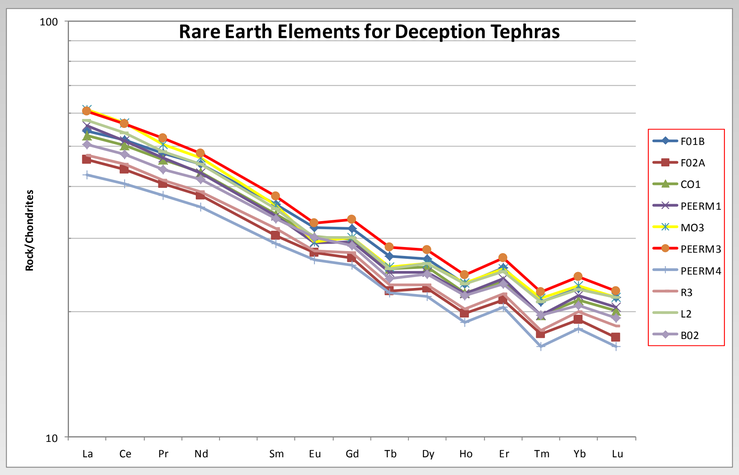


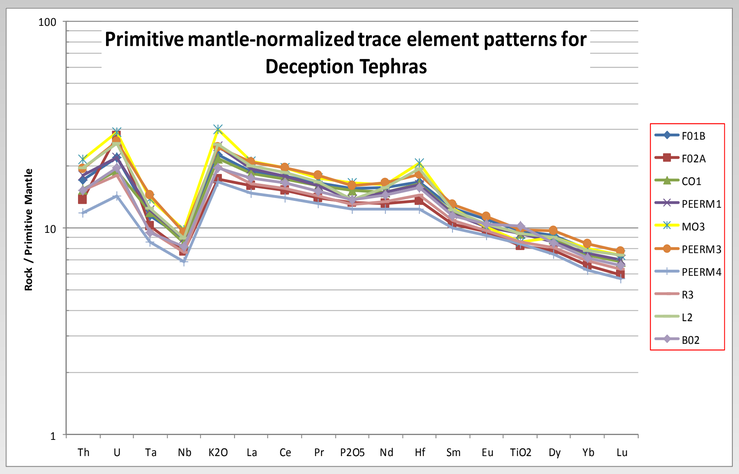
3. PETROGRAPHY, MAJOR AND TRACE ELEMENT GEOCHEMISTRY





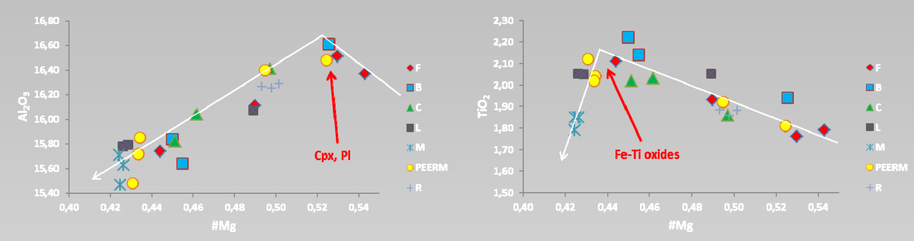
Petrographically, the biggest distinction identified on the samples studied is related with vesicularity: some samples have almost no vesicles (right sections), whereas the majority have a very significant amount of vesicles (in some case > 70% volume). They represent the exsolution of magma volatiles as the result of decompression. Higher the vesicle volume => higher volatile content. On the right photos visible a very fine and homogeneous matrix rich in Plagioclase (Pl), some Clinopyroxene (Cpx) and rare Olivine. Significant amount of opaque minerals (Ti-Fe oxides). On the left just to show the distinct matrix of the tephra – top, a microcrystaline matrix, rich in Pl and Cpx (note two generations of crystals). Below, a glass matrix – meaning that magma did not have time to crystallize any mineral (very rapid quenching).





Representative Masuda-Coryell plots of the Rare Earth Elements (REE) data for Deception Tephras indicate that in all samples the light REE (LREE) are enriched with respect to heavy REE (HREE) compared to chondrites. This enrichment is much more pronounced between LREE and MREE (middle REE). Based on the shape of the REE patterns and on the critical ratios commonly used to express the degree of fractionation among REE - (La/Yb)cn (varying between 2,34 and 2,65), (La/Sm)cn (1,46 - 1,65) and (Gd/Yb)cn (1,34 – 1,42), all samples have intermediate values between those of alkali basalts from Ocean Island Basalts (OIB) and Enriched MORB (E-MORB)[4]. When considering the High Field Strength Elements (HFSE) in the spider diagram, a major fact is emphasized - the Nb-Ta pronounced anomaly with respect to other similarly incompatible trace elements.

4. DISCUSSION



The magmas originating the tephra are differentiated (not primary magmas), having crystallizing mainly Olivine, Plagioclase, Clino-Pyroxene and only at the end Ti-Fe oxides.

Punta Murature samples (M) are distinguished from the rest of the samples, by their more incompatible-elements enriched character (more REE and HFSE concentrations, higher La/Yb, La/Sm, K_2O/TiO_2), probably related to mantle heterogeneities.

In subduction-related volcanic rocks, the HFSE display a characteristic depletion relative to the REE and Large Ion Lithophile elements (such as K) [5] despite their similar compatibility during mantle melting. This depletion is the consequence of mass flux processes from the subducting plate to the subarc mantle. Most arc magmas originate from subarc mantle wedge[6] which is enriched by fluids and melts from subducted oceanic crust and overlying pelagic sediments. Since HFSE have lower mobility during subduction metasomatism of the mantle, they will be depleted in the magmas originated in this tectonic environment.

Deception Island's Tephras show a pronounced depletion in Nb-Ta, together with a significant enrichment in the most incompatible elements, clearly emphasizing the relationship between the origin of Deception lavas with the subduction of the Phoenix tectonic plate under the Antarctic Plate.

5. REFERENCES

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(3) http://www.propolar.org/contantarc.html
(4) Sun, S.-S. & McDonough, W.F. (1989). Chemical and isotopic systematics of oceanic basalts: implications for mantle composition and processes. In: Saunders, A.D. & Norry, M.J. (eds) Magmatism in the Ocean Basins. Geological Society of London Special Publication 42, 313–345.
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